Patient Compliance with Recommendation of Physical and Cognitive Rest Following Concussion

A Senior Honors Thesis

Presented in Partial Fulfillment of the Requirements for graduation *with honors research distinction* in the undergraduate colleges of The Ohio State University

by:
Leon Bederman

The Ohio State University
May 2013

Project Advisor: Dr. Paul Gubanich, Department of Sports Medicine

INTRODUCTION

An important area of emphasis in the media and sports governing bodies during the past two decades has been the dilemma of traumatic brain injuries, namely concussions. As a result, efforts have been concurrently made to standardize the definition of a concussion, and in 2008 the International Conference of Concussion in Sport in Zurich reconfirmed it as the following: any head injury, either caused by a direct blow to the head or a blow elsewhere on the body with an "impulsive" force on the head, that temporarily impairs brain function. It was also agreed that while a concussion does not necessarily lead to a loss of consciousness, it can often result in a host of other physical, cognitive, and emotional symptoms that manifest themselves differently in different patients and can potentially result in long term sequelae.[6,13] This wide range of symptoms and reactions makes it difficult for the contemporary sports medicine physician or neurologist to effectively treat a concussion, and although extensive research over the last decade has improved our understanding of the concussion, the injury nevertheless continues to occur with significant frequency across all levels of sports participation.[17,18]

Recent literature has also indicated that concussion incidence continues to rise. During the period from 2000 to 2011, the incidence of concussion injury in high school athletes across each gender increased 4.2-fold.[1,3,7] Concussion incidence rates for sports participants in youth leagues have also seen an increase, more than doubling from 1997-2007 (as measured by emergency room visits caused by concussion).[3,5] Furthermore, rates for college athletes also continue to trend upward.[8] Though there has been speculation that these increases in incidence are a result of greater reporting of concussion injury, the fact remains that the contemporary sports medicine physician or neurologist has seen a large increase in patients presenting with concussions or concussion-like-symptoms. Although the literature reports that many of these patients spontaneously recover from post-concussive symptoms within 7 days, a significant minority of concussion patients experience symptoms beyond the time range of the "typical" course of recovery.[19, 20] A recent longitudinal study reported that 10% of its concussed participants experienced such prolonged recovery, some even requiring specialized neuropsychological care[18]. As such, continued research regarding the causes behind this prolonged recovery is required to improve current treatments and further develop more effective and evidenced-based treatment methods.

The current protocol used by sports medicine physicians for treating concussions was developed by an international coalition of physicians and researchers at the International Conference of Concussion in Sport in Zurich. Illustrated in Table 1, this protocol involves a graduated 6-step process that begins with "complete physical and cognitive rest," followed by gradual increases in exertion until the athlete is medically cleared for full competition participation.[6] Past research has shown that of the six steps in this protocol, physical and cognitive rest – that is, limiting television, text messaging, as well as school, work or sports activities – is the most important factor in effective concussion management.[6,9-12] Unfortunately, however, there is much anecdotal evidence to suggest that many concussion patients do not comply with this particular physician's recommendation. Moreover, a nationally-representative 2009 study reported that up to 40.5% of high school athletes during the period 2005-2008 returned to competition too early, as defined by the guidelines established in 1997 by the American Academy of

Neurology (AAN)[2]. Recently, these guidelines have been updated with a greater emphasis on concussion patient safety, suggesting that the percentage of non-compliant high-school athletes in the 2009 study could be even higher[21]. Thus, it is clear that concussion patient non-compliance with physicians' recommendations, specifically that of physical and cognitive rest, remains an important hurdle to concussion management and recovery.

It is thus the objective of this pilot study to both measure the patient's level of compliance with the recommendation of physical and cognitive rest by objectively measuring their physical and cognitive activity post injury, and to examine if and to what extent this (non-) compliance has an exacerbating effect on length of recovery or symptom severity. If it is demonstrated that there exists a possibility of noncompliance resulting in exacerbation of symptoms or lengthening of recovery time, this study can serve as the groundwork for a more expansive study.

METHODS

Design and procedure

The current study is a case-control study. Cases were recruited from the sports medicine clinic of one provider at the Wexner Medical Center during the period February 1st – March 31st. Controls were non-concussed individuals recruited via flyers around the Ohio State University campus. The goal of the current study was to recruit thirty participants to each group. Concussed participants must have suffered an acute concussion within seven days of presenting at the sports medicine clinic. Participants with allergies to metal or who had an implantable heart monitor were also excluded, as those were contraindications to use of the armband accelerometer employed in this study.

Non-concussed control group participants were subject to the similar criteria for participation as concussed participants. All participants must have been 10 years of age or older prior to beginning the study.

Each concussed participant was part of the study for a total of two weeks, meeting with the principal investigator once per week for a total of three interactions. During visit one, the patient was first educated on the pathophysiology of concussion injury as well as the importance of physical and cognitive rest and risk factors for recovery. The patient was then informed about proper use of the accelerometer, consented, and fitted with a calibrated accelerometer and surveys to complete over the following week. This process was repeated during the patient's second visit, along with instructions for rest and activity adjusted for their appropriate recovery and progression. During the third visit, the patient was debriefed from the study and all surveys and accelerometers were collected. The patient's care then continued as dictated by their recovery and progression from injury. Non-concussed control participants underwent similar monitoring and instruction during their two week participation in the study.

This study was approved by the institutional review board for human subjects protection at the host university of the principal investigator (Dr. Paul Gubanich). Written informed consent was obtained from all participants and/or their parents/guardians prior to participation in the study.

Instrumentation and measures

The study incorporated three primary measures: an accelerometer for objectively capturing levels of physical activity, questionnaires for self-reporting duration of physical and cognitive activity, and a symptom checklist for self-reporting severity of symptoms.

The SenseWear Armband Accelerometer used in this study is a small device that is attached to an armband. It is usually worn on the participant's non-dominant arm, above the elbow. Participants were instructed to wear the accelerometer continuously over the course of the study and only to remove it in order to bathe or if it was causing excessive discomfort. The key to this armband's usefulness is that it does not require uncomfortable measurements in a laboratory – it can be worn comfortably during a person's normal life[16], which may have served to increase participant compliance with wearing the accelerometer.

For the purposes of the current study, the accelerometer was used to measure levels of physical activity such as steps taken, joules of energy expended, how often participants slept, and times during which it was taken off. The accelerometer also recorded joules expended and time spent above a certain MET level (Metabolic Equivalent of Task, a measure of the energy cost of various physical activities). These devices have previously been validated for use in measuring energy expenditure during exercise and daily activity.[14,15] The current study employed a MET level of 3 as its minimum for physical activity, which is the MET level associated with light activity such as walking, archery, vacuuming, mopping, or slowly climbing stairs.

As previously stated, the second measure was a short questionnaire that participants filled out each day of their two week participation in the study. This questionnaire detailed the number of minutes participants spent performing physical and cognitive activity over the course of the week. The third measure was a symptom checklist that participants filled out each day. This checklist was based on the SCAT-2 (Sports Concussion Assessment Tool version 2), a widely employed concussion screening tool that was updated in 2008 by the group attending the Zurich conference. The checklist asked participants to rate the severity of a number of symptoms associated with concussion on a scale from 0-6.

RESULTS

The current study is ongoing and actively recruiting participants. This analysis was performed as an interim assessment to meet the needs of the honors undergraduate thesis. Eighteen controls were recruited and completed their two week participation in the study. Four concussed individuals have been enrolled, two of whom have completed their two week participation in the study. Both concussed participants who completed the study were male (there is one other male and one other female). As a result of the ongoing nature and small sample size of the current study, as well as the relatively large demographic differences between the two concussed participants, the data gleaned from each concussed participant will be treated and examined individually.

Tables 2a and 2b present the statistics for data provided by the accelerometer – specifically the daily average METs, the daily average amount of energy expended above a MET level of 3, the daily average time spent above this same MET level, as well as the standard deviations for all three measures. Tables 3a and 3b display daily means and standard deviations for self-reported symptom checklist categories for weeks one and two. Comparisons between controls and concussed participants in terms of their self-reported physical and cognitive activity, as well as their symptoms, are illustrated in Figures 1-3.

Participant One

Participant one, henceforth referred to as Patient X, was a 22 year old male who was seen at intervals of 10 days. Data for the second week of self-reported physical and cognitive activity, as well as for the first week of accelerometer-wearing, is missing.

In terms of physical activity over the course of the first week, Patient X seems to have had a steadfast compliance with the physician's recommendation of complete physical rest (Figure 2). He spent significantly less time than controls performing light aerobic activity (walking, mopping), and spent virtually no time performing sport specific exercises (running, skating) or training drills (weight training, resistance training). However, as is anecdotally often the case, Patient X struggled to comply with recommendations for cognitive rest (Figure 3). He spent essentially the same amount of time per day as controls surfing the web, attending class, hanging out with friends, reading, and using his mobile phone to text or play games. Finally, accelerometer data from week two illustrates that Patient X was more active on a daily basis than controls, with his daily average METs, daily energy expenditure, and daily physical activity duration exceeding those of controls (Table 2b). This heavy increase in activity level during week two, however, may be reflexive of spontaneous recovery from symptoms, as is evidenced through examination of the self-reported symptom scores from Patient X.

Participant Two

Participant two, henceforth referred to as Patient Y, was a 65 year-old male who was seen at intervals of 7 days and suffered a slightly more severe concussion than Patient X. Data for the second week of self-reported physical and cognitive activity, as well as for the second week of accelerometer-wearing, is missing. It should also be noted that Patient Y only wore the accelerometer for a total of a half-day during the first week.

With regards to physical activity during the first week, Patient Y seems to have disregarded the recommendation of complete physical rest (Figure 2). Compared with controls, he spent an equal amount of time each day performing light physical activity, though he spent no time performing sport specific and non-contact training exercises. It is also conceivable that the limited accelerometer data available for week one supports the self-reported data. Through one half-day of wearing the accelerometer, Patient Y expended roughly half of the joules expended by controls during a full day, and also spent nearly as much time performing physical activity in a half day as controls during a full day. Patient Y's MET level during the time that he wore the accelerometer also virtually matched the daily average MET level for controls (Table 2a). Patient Y also seemed to struggle with certain aspects of complete cognitive rest (Figure 3). Through week one, Patient Y spent similar or equal amounts of time per day as controls using his phone, watching television, surfing the web, and performing homework or work-related activities.

DISCUSSION

Though the small sample size of the study does not have enough statistical power to result in conclusive theories, there are several interesting aspects of the current study that merit further investigation.

According to the self-reported symptom scores, Patient X initially suffered significant increases versus controls in discomfort or pain for a number of typical concussion symptoms, most notably fatigue, drowsiness, and not feeling "right." By week two of participation in the study, however, these symptoms had effectively resolved. Although most likely the result of spontaneous recovery, the possibility exists that this alleviation of symptoms was expedited by Patient X's better compliance with the recommendation of complete physical rest than Patient Y (despite Patient X's non-compliance with cognitive rest). Moreover, Patient Y also failed to comply with the recommendation of cognitive rest, and potentially as a result, his symptom scores from week one to week two remained largely the same. This very preliminary data presents the possibility that there may exist a short 7-10 day window immediately following concussion injury during which complete physical and cognitive rest may drastically improve the future clinical course of the injury. In recent years, one publication has also hinted at a similar conclusion (that a 7-10 day window exists immediately post-injury during which re-injury risk is the highest), however more research needs to be done in order to confirm or deny this suggestion.[4]

Another interesting point to note is that both concussed participants reported a certain level of non-compliance with the physician's recommendation of complete physical and cognitive rest. This finding supports current anecdotal evidence, and also helps to illustrate what specific physical and cognitive activities may tempt or lead patients towards non-compliance. With regards to cognitive activity, both concussed participants showed similar levels of cell phone usage and surfing the web (and to a lesser extent, reading) to controls. In terms of physical activity, Patient Y demonstrated similar levels of light physical activity as controls. Though more data remains to be collected regarding these specific instances of non-compliance, these findings nevertheless help to better define patient non-compliance after a concussion injury. Acquiring a more accurate knowledge of the types of activities and habits that tempt people into non-compliance may allow the modern physician to better coach their patients against non-compliance and better emphasize the importance of physical and cognitive rest. Indeed, in a field where injury management is already complex – and where coaches, teachers, parents, or bosses often inadvertently (or overtly) pressure the patient into premature physical or cognitive activity[2] – an accurate understanding of non-compliance and its potential effects on the clinical course of recovery from concussion is essential.

There are several limitations to this study that require consideration. As previously mentioned, the sample size of concussed patients and controls precludes any sort of statistically significant finding. Moreover, controls in this study were not matched to concussed patients based on gender, and in the case of Patient Y, were also not matched based on age. This introduces several potential confounding factors that need to be mitigated prior to achieving statistically significant results. It should also be mentioned that both concussed patients were male and data gathered from both speaks only to the effects of a single concussion over the course of two weeks. At the current time, there is a great need for both more information on the effects of gender during concussion recovery, as well as more research into the probable cumulative physical, emotional, and neurological effects of multiple concussions. Thus, further study is required in order to address these concerns.

Despite these limitations, the current study nevertheless sets a foundation for further research into previously un-examined topics in concussion management. It has demonstrated the possibility that without the appropriate physical and cognitive rest (potentially within or during the appropriate timeline), recovery and symptom alleviation during the two weeks following a concussion injury may be prolonged. It has also demonstrated that there are a number of activities that may tempt patients into non-compliance. Further and more extensive research is required in order to clarify if certain non-compliant activities lead to the exacerbation of certain symptoms (or even to cognitive or behavioral dysfunction) or to the lengthening of recovery from symptoms. This, in combination with the knowledge gained from the current study, may help physicians to both better coach their patients against non-compliant activities as well as devise interventional strategies for those patients who refuse to comply with the recommendation of physical and cognitive rest.

TABLES AND FIGURES

Table 1. Graduated return to play protocol as recommended by the International Conference on Concussion in Sport in 2008**.**

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70%. No resistance training.	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, e.g. passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination, and cognitive load
5. Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Table 2a. Daily average values for accelerometer data from week one. A higher MET level indicates greater energy expenditure

Week 1	METs	Active Energy Expenditure (joules)	Physical Activity Duration (hrs)
Controls	1.58 (0.18)	2282.2 (912)	1.76 (.74)
Patient X	-	-	-
Patient Y	1.6	1077	1.25

Table 2b. Daily average values for accelerometer data from week two. A higher MET level indicates greater energy expenditure

Week 2	METs	Active Energy Expenditure (joules)	Physical Activity Duration (hrs)
Controls	1.55 (0.25)	2304.9 (1362)	1.78 (1.09)
Patient X	2.3	3009	2.98
Patient Y	-	-	-

Table 3a. Means and standard deviations for daily average symptom scores during week one. A higher score represents a more severe symptom.

		headache	pressure in head	neck pain	nausea or vomiting	dizziness	blurred vision	balance problems	light sensitivity	sound sensitivity	feeling slowed down	feeling like "in a fog"
Patient X	Mean	1.07	1.57	1.71	0.14	0.00	0.00	0.29	0.29	0.29	1.43	1.00
	STDEV	1.02	1.51	1.11	0.38	0.00	0.00	0.76	0.49	0.49	0.79	0.58
Patient Y	Mean	0.14	1.43	2.29	0.57	1.50	0.14	2.86	3.86	4.00	3.00	2.71
	STDEV	0.38	0.53	0.76	0.53	1.22	0.38	0.90	0.38	0.00	1.00	0.76
Controls	Mean	0.24	0.06	0.05	0.05	0.06	0.01	0.00	0.05	0.01	0.22	0.03
	STDEV	0.63	0.35	0.25	0.28	0.29	0.09	0.00	0.25	0.09	0.67	0.25
		don't feel right	difficulty concentrating	Difficulty Remembering	fatigue or low energy	confusion	drowsiness	trouble falling asleep	more emotional	irritability	Sadness	nervous or anxious
Patient X	Mean	1.86	0.00	0.21	3.00	0.00	2.86	0.00	0.00	0.29	0.00	0.57
	STDEV	1.21	0.00	0.39	0.82	0.00	0.69	0.00	0.00	0.49	0.00	0.98
Patient Y	Mean	3.00	2.43	2.00	3.57	1.14	2.71	0.86	2.00	0.43	1.29	2.71
	STDEV	1.15	0.53	1.00	0.79	0.90	0.76	1.07	1.29	0.53	0.95	0.76
Controls	Mean	0.09	0.25	0.02	0.41	0.02	0.11	0.27	0.10	0.13	0.11	0.23
	STDEV	0.42	0.59	0.18	0.84	0.13	0.40	0.64	0.50	0.51	0.46	0.76

Table 3b. Means and standard deviations for daily average symptom scores during week two. A higher score represents a more severe symptom.

		headache	pressure in head	neck pain	nausea or vomiting	dizziness	blurred vision	balance problems	light sensitivity	sound sensitivity	feeling slowed down	feeling like "in a fog"
Patient X	Mean	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	STDEV	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patient Y	Mean	0.14	1.00	2.71	0.29	1.71	0.00	3.14	3.29	3.29	2.57	2.86
	STDEV	0.38	0.00	0.76	0.49	1.25	0.00	0.90	0.49	0.49	0.53	0.69
Controls	Mean	0.25	0.05	0.03	0.13	0.02	0.01	0.00	0.00	0.00	0.21	0.06
	STDEV	0.83	0.22	0.18	0.70	0.13	0.09	0.00	0.00	0.00	0.59	0.27

		don't feel right	difficulty concentrating	Difficulty Remembering	fatigue or low energy	confusion	drowsiness	trouble falling asleep	more emotional	irritability	Sadness	nervous or anxious
Patient X	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	STDEV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Patient Y	Mean	3.43	2.71	2.29	2.71	1.71	2.14	2.00	2.86	2.43	2.57	3.14
	STDEV	0.79	0.76	0.49	0.49	0.95	0.90	1.41	1.35	0.79	1.40	1.07
Controls	Mean	0.07	0.28	0.01	0.43	0.00	0.15	0.24	0.06	0.05	0.06	0.19
	STDEV	0.56	0.73	0.09	0.90	0.00	0.53	0.71	0.32	0.46	0.29	0.63

Figure 1a. Mean daily scores for a range of symptoms commonly associated with concussion during week one. A higher score represents a more severe symptom.

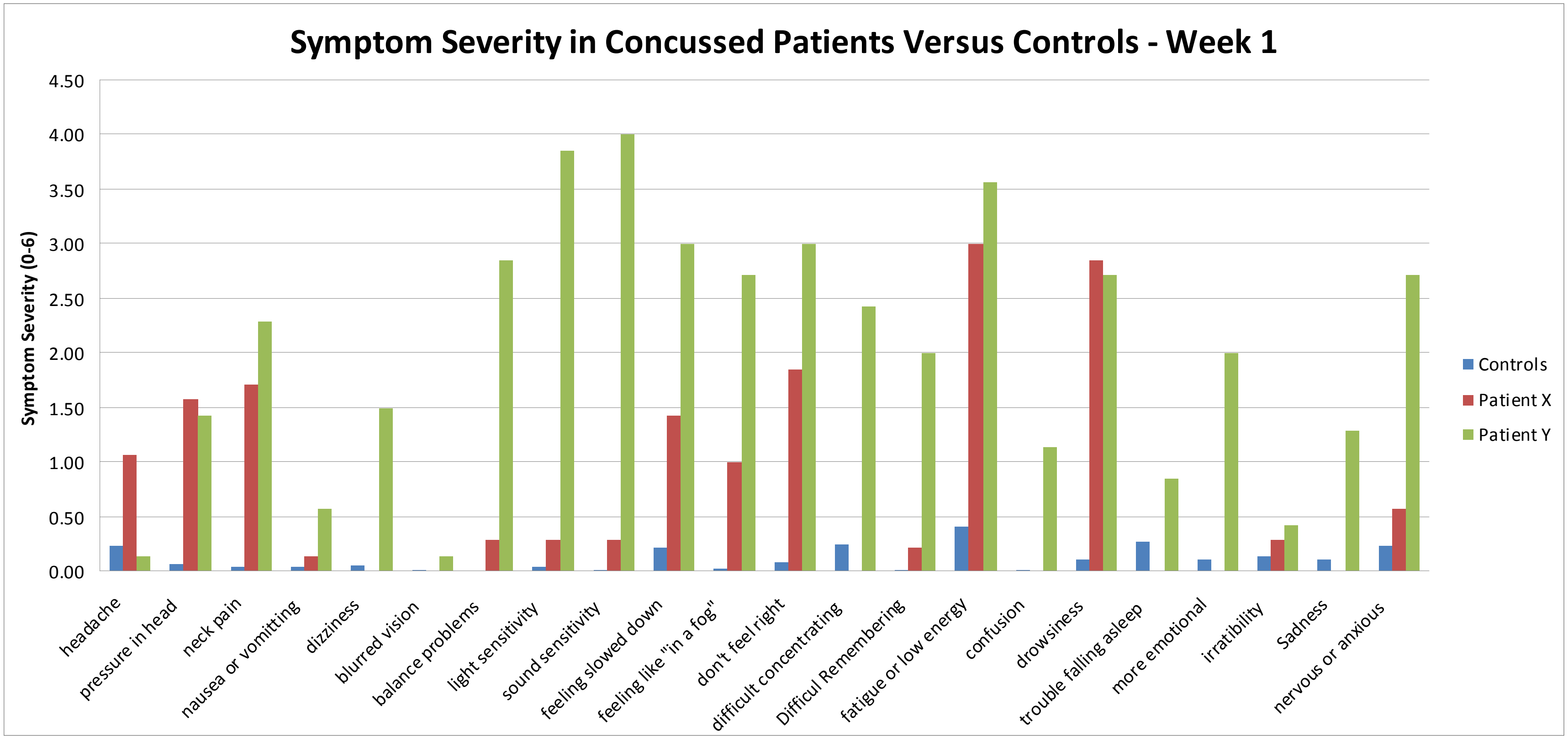


Figure 1b. Mean daily scores for a range of symptoms commonly associated with concussion during week one. A higher score represents a more severe symptom.

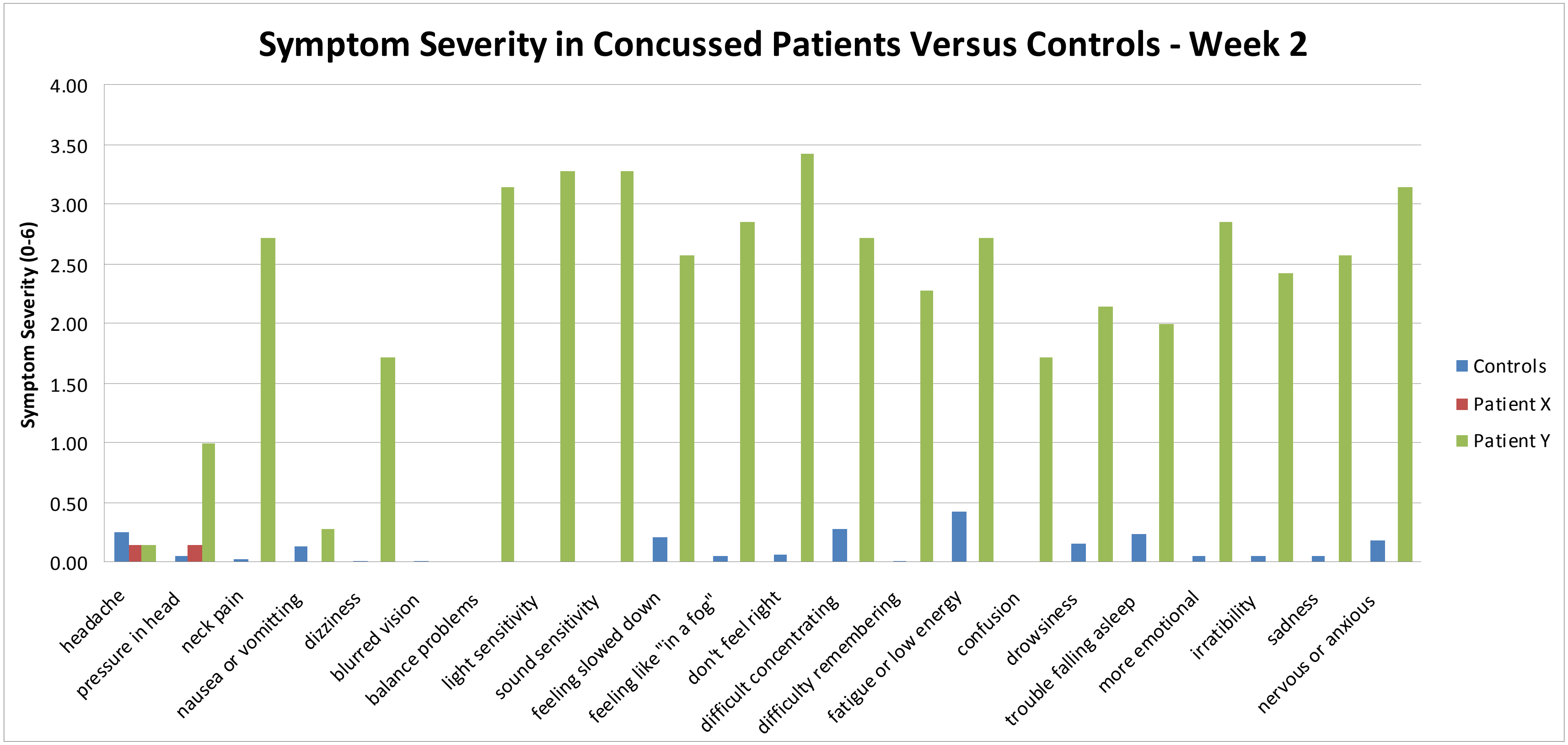


Figure 2. Mean daily duration (in minutes) of physical activity during week one.

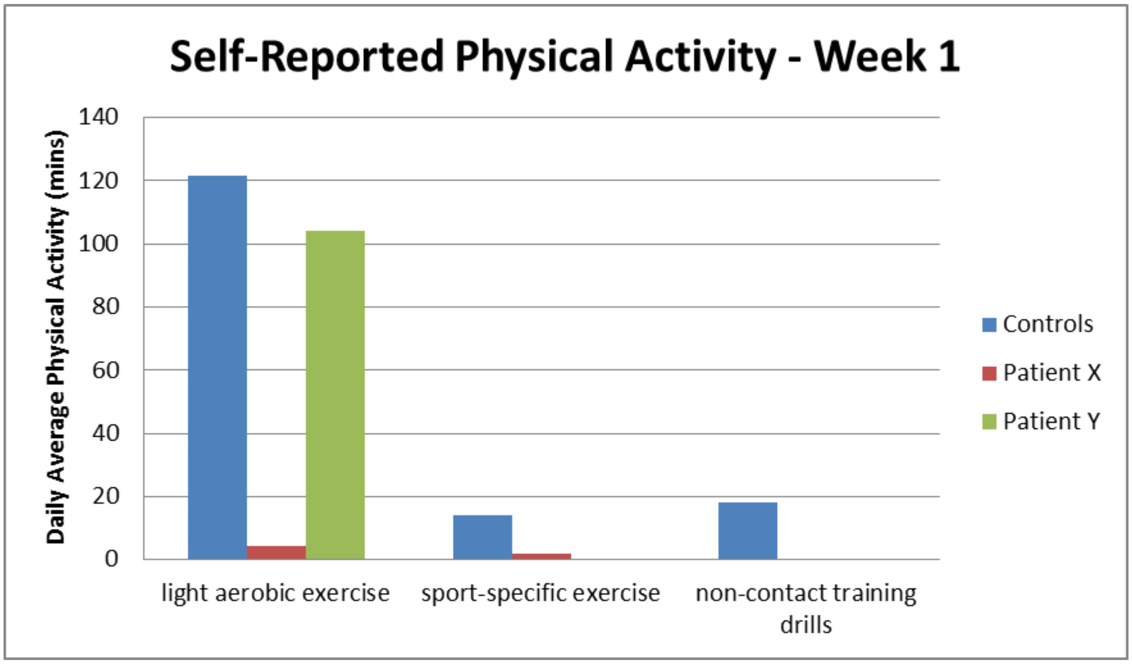
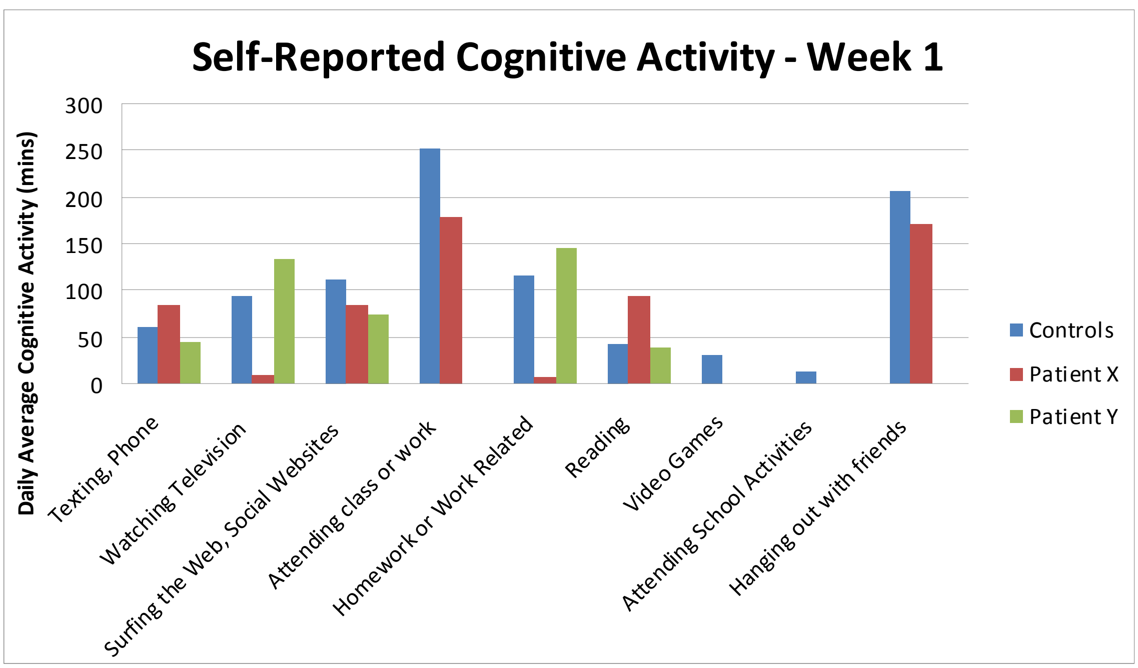


Figure 3. Mean daily duration (in minutes) of cognitive activity during week one.



REFERENCES

1. Marar M, McIlvain NM, Fields SK, Comstock RD. 2012. Epidemiology of concussions among United States high school athletes in 20 sports. American Journal of Sports Medicine 40: 747-755.
2. Yard EE, Comstock RD. 2009. Compliance with return to play guidelines following concussion in US high school athletes. 2005-2008. Brain Injury 23: 888-898.
3. Daneshvar DH, Nowinski CJ, McKee A, Cantu RC. 2011. The epidemiology of sports-related concussion. Clinical Sports Medicine 30: 1-17.
4. McCrea M, Guskiewicz K, Randolph C, Barr WB, Hammeke TA, Marshall SW, Kelly J. 2009. Effects of a Symptom-Free waiting period on clinical outcome and risk of reinjury after sport-related concussion. Neurosurgery 65: 876-83.
5. Meehan WP, Bachur RG. 2009. Sport-related concussion. Pediatrics 123: 114-123.
6. McRory P, Meeuwisse W, Johnston K, Dvorak J, Aubry M, Molloy M, Cantu R. 2009. Consensus statement on concussion in sport – the 3rd International Conference on concussion in sport, held in Zurich, November 2008. Journal of Athletic Training 44: 434-448.
7. Lincoln AE, Caswell SV, Almquist JL, Dunn RE, Norris JB, Hinton RY. 2011. Trends in concussion incidence in high school sports, a prospective 11-year study. The American Journal of Sports Medicine 39: 958-963.
8. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. 2007. Concussions among United States High School and Collegiate Athletes. Journal of Athletic Training 42: 495-503.
9. Halstead ME, Walter KD, Council on Sports Medicine and Fitness. 2010. Clinical Report – Sport-related concussion in children and adolescents. Pediatrics 126: 597-615.
10. Reddy CC, Colins MW. 2009. Sports concussion: management and predictors of outcome. Current Sports Medicine Reports 8: 10-15.
11. Johnston KM, Bloom GA, Ramsay J, Kissick J, Montgomery D, Foley D, Chen JK, Ptito A. 2004. Current Concepts in Concussion Rehabilitation. Current Sports Medicine Reports 3: 316-323.
12. Canadian Academy of Sports Medicine. 2000. Guidelines for assessment and management of sport-related concussion. Clinical Journal of Sports Medicine 10: 209-211.
13. Kerr ZY, Marshall SW, Harding HP Jr, Guskiewicz KM. 2012. Nine-year risk of depression diagnosis increases with increasing self-reported concussions in retired professional football players. American Journal of Sports Medicine. [Epub ahead of print].
14. St-Onge M, Mignault D, Allison DB, Rabasa-Lhoret Rémi. 2007. Evaluation of a portable device to measure daily energy expenditure in free-living adults. American Journal of Clinical Nutrition 85: 742-749.
15. Jakicic JM, Marcus M, Gallagher KI, Randall C, Thomas E, Goss FL, Robertson RJ. 2004. Evaluation of the SenseWear Pro Armband to assess energy

expenditure during exercise. Medicine and Science in Sports and Exercise 36:897-904.
16. Polzein KM, Jakicic JM, Tate DF, Otto AD. 2007. The efficacy of a technology-based system in a short-term behavioral weight loss intervention. Obesity 15:825-830.
17. Guskiewicz, KM; Weaver, NL; Padua, DA; Garrett, WE Jr. 2000. Epidemiology of concussion in collegiate and high school football players. American Journal of Sports Medicine 28: 643-650.
18. McCrea M, Guskiewicz K, Randolph C, Barr WB, Hammeke TA, Marshall SW, Powell MR, Ahn KW, Wang Y, Kelly JP. 2012. Incidence, Clinical Course, And Predictors of Prolonged Recovery Time Following Sport-Related Concussion in High School and College Athletes. Journal of the International Neuropsychological Society 18: 1-12.
19. Anderson T, Heitger M, Macleod AD. 2006. Concussion and mild head injury. Practical Neurology 6: 342-357.
20. McClincy MP, Lovell MR, Pardini J, Collins MI, Spore MK. 2006. Recovery from sports concussion in high school and collegiate athletes. Brain Injury 20: 33-39.
21. Giza CC, Kutcher JS, Ashawl S, et al. [Published online ahead of print March 18, 2013]. Summary of evidence-based guideline update: Evaluation and management of concussion in sports: Report of the Guideline Development Subcommittee of the American Academy of Neurology. Neurology 1-7.